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# M1-E2 mixing ratio and the nuclear structure parameter for the 161 keV transition in $^{133}$Cs

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The $M1$–$E2$ mixing ratio and the nuclear structure parameter have been accurately determined for the 161 keV transition in $^{133}$Cs from an analysis of $L$-subshell intensity ratios employing the recent theoretical tabulations of Hager and Seltzer for the conversion ratios and the penetration functions thus obtaining $\delta^2 = 1{\cdot}35^{+0{\cdot}085}_{-0{\cdot}06}$ and $-1 < \lambda < -8$ supporting the $\alpha_k$ value of 0·21.

## 1 INTRODUCTION

The 161 keV gamma transition between the $5/2^+$ 161 keV level and the $7/2^+$ ground state of $^{133}$Cs is a predominently $M1$ transition with a small $E2$ admixture and with an $M1$ retardation of $\sim 320$. There have been a number of attempts to determine the $M1$–$E2$ mixing ratio through the internal conversion coefficient measurements and gamma-gamma directional correlation studies The mixing ratios derived from directional correlations and $\alpha_k$ measurements did vary widely as can be seen from the table Since this transition is 1-forbidden and the retardation is a common condition for the presence of nuclear structure effects, attempts have also been made to determine the penetration parameter in all the above cases But neither the $\alpha_k$ nor the gamma-gamma correlation data could agree with each other. Till now there has been no attempt to estimate the nuclear structure parameter $\lambda$ using exclusively the experimental $L$-subshell ratios In the present work the experimental $L$-subshell ratios of Tornkvist *et al* (1970) are analysed using the recent theoretical tabulations of Hager & Seltzer (1968) for conversion coefficients and penetration functions (Hager & Seltzer 1969) to estimate the penetration parameter simultaneously obtaining the exact mixing ratio taking into consideration the nuclear structure parameter $\lambda$

## 2 ANALYSIS

The experimental data of Tornkvist *et al* (1970) has been analysed using the relation between $\lambda$ and $\delta^2$ involving the penetration functions $B1$ and $B2$ in different sub-shells and the theoretical sub-shell ratios interpolated from Hager & Seltzer tables

$$\delta^2 = \frac{1}{(L_1/L_2)L_2(E2)-L_1(E2)}\left[L_1(M1)-\left(\frac{L_1}{L_2}\right)L_2(M1)+\lambda\left\{L_1(M1)B1(L_1)\right.\right.$$
$$\left.\left.-\left(\frac{L_1}{L_2}\right)L_2(M1)B1(L_2)\right\}\right] \text{ for } \quad |B1| >> |B2|.$$

Figure shows the plot of $\lambda$ vs $\delta^2$ for each of the intensity ratios. The statistical error bands for each of the lines, arising out of the experimental errors in intensity ratios, are also shown in the figure. The overlapping areas of the three bands is shaded in the figure The most probable values for $\lambda$ and $\delta^2$ are deduced from the figure from the centre of gravity of the shaded areas

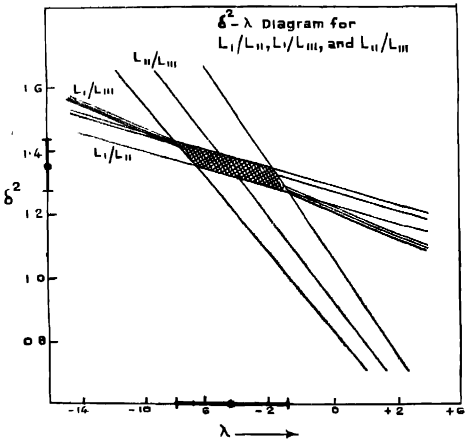


Fig. 1, Analysis of L-sub-shell intensity ratios.

## 3 Results

Table 1. $M1$–E2 mixing ratio and penetration parameter

| Author | Measurement | $\delta^2$ | $\lambda$ |
|---|---|---|---|
| Vin *et al* (1964) | $\alpha_k$ | 8 8 | $-55\pm40$ or $305\pm40$ |
| Bodenstedt *et al* (1959) | $\alpha_k$ | 0 1 | $-25\pm30$ or $270\pm30$ |
| Bosch *et al* (1967) | $\alpha_k$ | 0·0 | $-20\pm15$ or $225\pm15$ |
| Tornkvist *et al* (1970) | $\alpha_k$, $\gamma-\gamma$ $K/L_3$ | $0{\cdot}46\pm0\ 06$ | $5\pm15$ $240\pm10$ |
| Meder *et al* (1970) | $\gamma-\gamma$ | $0\ 41\pm0{\cdot}03$ | $40^{+12}_{-15}$ $4^{+8}_{-4}$ |
| Avignone *et al* (1970) | $e_3-\gamma$ $K/L+M$ | $1{\cdot}10^{+0\ 30}_{-0\ 22}$ | $40\pm15$ |
| Hennecke *et al* (1967) | $K/L_3$, $L_1/L_3$, $\gamma-\gamma$ | $0{\cdot}39\pm0{\cdot}015$ | $45\pm10$, $180\pm20$ |
| Freund *et al* (1973) | $\alpha_k$ | – | $8\ 6\pm3{\cdot}4$ |
| | | — | $52\pm19$ |
| Schmidt *et al* (1972) | $\alpha_k$ | 0 34 | $7{\cdot}8\pm5{\cdot}5$ |
| | $\alpha_k$ | 0 41 | $7{\cdot}1\pm5{\cdot}5$ |
| Present work | $L_I/L_{II}$ $L_I/L_{III}$, $L_{II}/L_{III}$ | $1{\cdot}35^{+0\ 005}_{-0\ 08}$ | $-1 < \lambda < -8$ |

As can be seen from the table the error associated with the mixing ratio of the present work is only $\sim$5% compared to the nearly 25% on the earlier results and the range of $\lambda$ is also small The present results are in agreement with those of Schmidt *et al* (1972). It shows that the sub-shell intensity ratios are the best data to obtain the mixing ratios very accurately and the ranage of the nuclear structure parameter very precisely The discrepancies among the reported results on $\delta^2$ is only due to the discrepancies in the measured $\alpha_k$ values In the present analysis the simultaneous evaluation for $\lambda$ and $\delta^2$ has facilitated to get mixing ratio corrected for the nuclear structure effect through the parameter $\lambda$ between $-1$ and $-8$ Avignone *et al* (1970) pointed out from their results that the most likely value of the $\alpha_k$ for the 161 keV transition is 0·095 with $\lambda = 163$ The present results agree with the mixing ratio and the lower value of $\lambda$ obtained by Tornkvist *et al* (1970) from their $\alpha_k$ value and therefore supports the $K$-conversion coefficient of 161 keV to be $0{\cdot}21 \pm 0{\cdot}03$. It can not however be so low as given by Avignone *et al* (1970) with such a high value of $\lambda$ Hennecke *et al* (1967) analysed the sub-shell ratios, using the theoretical tabulations of Sliv & Band (1956) and hence the discrepancy

In conclusion the present results confirmed the presence of dynamic nuclear structure effects in the 161 keV transition in $^{133}$Cs and also enabled the determination of an accurate $M1$–$E2$ mixing ratio of this transition

## References


Avignane F. T & Frey G. D. 1970 *Phys Rev* **C1**. 635

Bodenstedt E., Kroner J H., & Mathias E. 1959 *Nucl. Phys.* **11**, 584.

Bosch H E, Srichman E., Bassegio A. & Dohnkue R. 1967 *Nuc Inst. Meth.* **52**.

Freund E. 1973 *Z. Phys* **264** 259.

Hager R & Seltzer E. 1968 *Nucl Data* **A4**. 1–127.

Hager R. & Seltzer E 1969 *Nucl Data* **A6** 1–125.

Hennecke H J, Hanthuruthil J. C & Bergman O. 1967 *Phys. Rev.* **159**. 955

Moder M R 1970 *Phys. Rev* **C1** 1085

Schmidt W. D & Fink R W. 1972 *Z. Phys.* **249** 286

Sliv L A & Band I M. 1956 Report 57 ICC K1 Physics department University of Illinois

Tornkvist S, Hasselgren L, Stran S, Thun J. E. & Antman S 1970 *Nucl. Phys.* **A142**. 238.

Vin L J & Wiedenbeck M, L, 1964 *Nucl Phys* **54**. 86.